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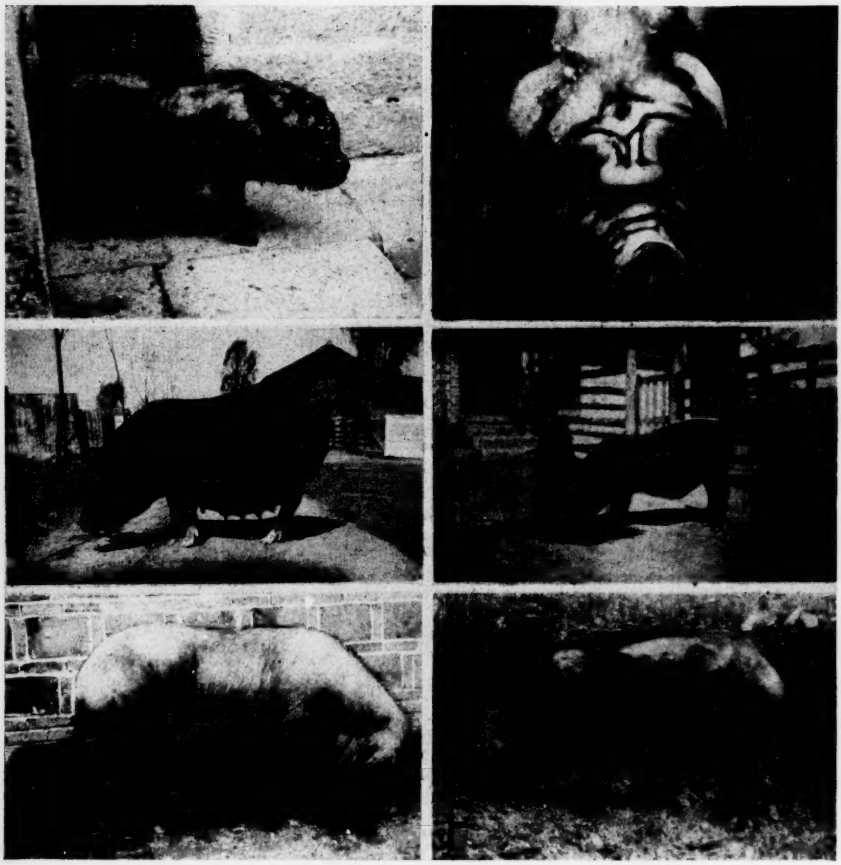

CHINESE PIGS
(SEE PAGE 365)

Colchicine Induced Mixoploids

A Toe-Clipping Gene

Spotted Pheasants

VOLUME 35 DECEMBER, 1944 NUMBER 12

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The JOURNAL OF HEREDITY is published monthly by the AMERICAN GENETIC ASSOCIATION at 32nd Street and Elm Avenue, Baltimore, Md., and 1108 Sixteenth St., N. W., Washington, D. C. Address all communications regarding editorial matters to Room 205, 1108 Sixteenth St., N. W., Washington, D. C. Communications regarding the business management of THE JOURNAL OF HEREDITY may be addressed to the publication office, 32nd Street and Elm Avenue, Baltimore, Md., or to 1108 Sixteenth St., N. W., Washington 6, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in section 1103, Act of October 3, 1917, authorized December 29, 1918.

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The

Journal of Heredity

Vol. XXXV **DECEMBER, 1944** **No. 12**

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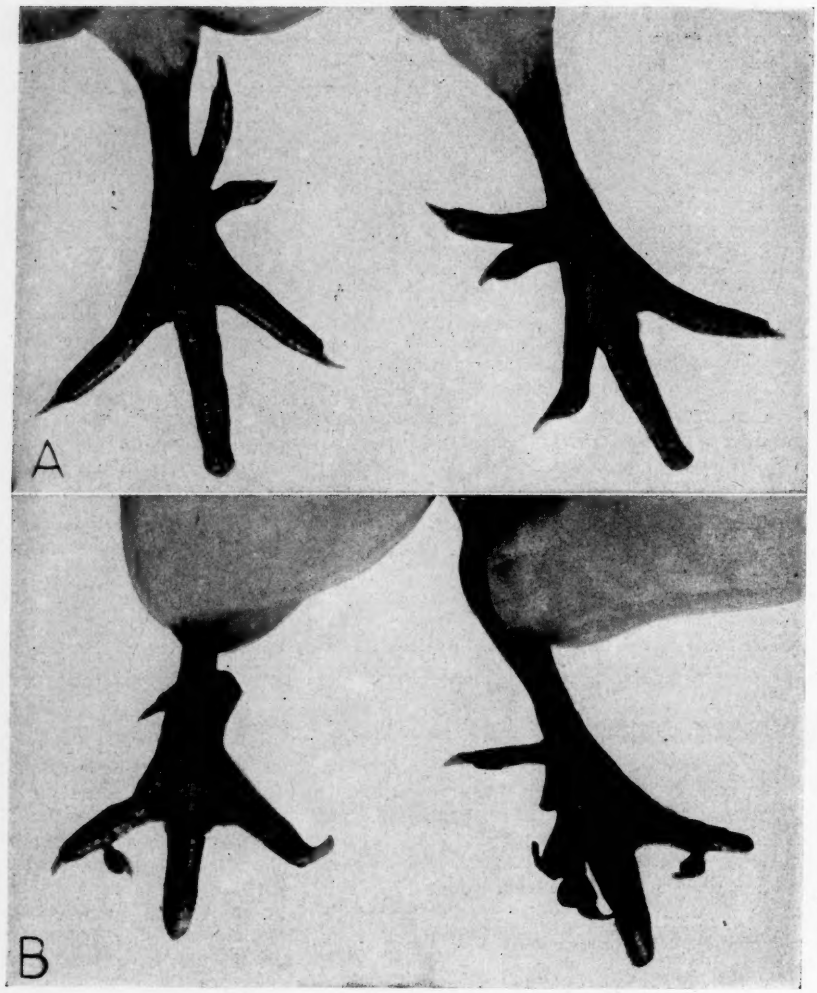

VARIATION IN EXTENT OF TOE DEFECT

Figure 1

A—A bird showing ungual osteodystrophy on both feet but limited to digit III. *B*—Ungual osteodystrophy expressed in digits II, III and IV. The nails are in some instances misplaced and attached to the side of the toe.

INHERITANCE OF UNGUAL OSTEODYSTROPHY IN THE FOWL

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THIS character was first noted in 1939 among the birds carried for genetic studies at Cornell University and Kansas State College. The data obtained at the two institutions have been combined for this publication. It is not to be implied that the appearance of the trait at the two institutions constitutes simultaneous mutations, for it seems more probable that each case was a chance observation of the segregation of a pre-existing recessive gene.

Description

The expression of ungual osteodystrophy is quite variable. In the minimum expression of this abnormality one or more of the nails point at an angle from the median line of the toe, or an inconspicuous cartilaginous spur appears beside the nail on one or more toes. The most extreme cases noted were of two birds all of whose digits showed some degree of defectiveness. The most common variation was that in which the ungual phalanx was absent, shortened, or distorted on the middle toe (Digit III) of one or both feet. This condition was frequently accompanied by defects in other toes as well. The expression of the character was similar in stocks carried independently at the two institutions. Since the toenails may become deformed or worn off in later life, the day-old-chick stage is probably the most dependable age at which to identify the character.

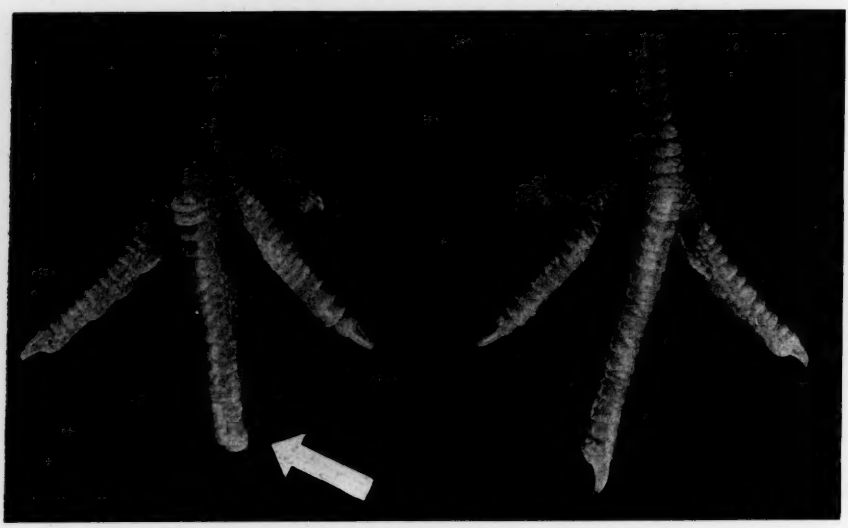
Distribution among different digits. The data on the incidence of defective toenails in 112 birds, as given in Table I show clearly that the middle toe (D III) is affected more often than all the other toes taken together. The data in Table I are self-explanatory as far as the unilateral occurrence of the abnormality is concerned, but require a note of interpretation in the case of birds with both feet affected. There were nine birds with the nail lacking on D III of both feet, and four with the nail present but abnormal on both feet, neither class showing any other abnormality. In six birds the nail of D III was bilaterally absent, and, in addition, other toes had nails lacking or abnormal. In seven birds, the nail of D III was present on both feet, but abnormal, together with defects in the nails of other digits.

Considering that 34 birds had abnormalities on both feet and 78 had them on one foot only, there were altogether among these 112 birds 146 feet that showed some degree of abnormality. In 111 of these, or 76 per cent, D III was affected.

Furthermore, on these 146 feet there were 168 toes that showed some degree of the abnormality. The nail was lacking in 111, or 65 per cent, and short, crooked, or otherwise defective in the remaining 35 per cent. Apparently the mutation causes elimination of a terminal phalanx more often than some lesser abnormality, but the possibility remains that there may be "normal overlaps," *i.e.*, birds showing no abnormality whatever, though having the genotype that usually causes some manifestation of the condition.

It is perhaps desirable to point out that, although the abnormality appears to consist of missing, defective, or ab-

*Contribution No. 161 from the Department of Poultry Husbandry, Kansas State College.
†No. 19 in the series by F. B. Hutt, entitled "Genetics of the Fowl."



ONE FOOT AFFECTED

Figure 2

Ungual osteodystrophy exhibited in digit III of the right foot only. Although there is considerable variability in expression of this character, it is the long middle toe which most frequently shows the missing or defective toenail.

normal toes, it is not a true anonychia, but rather a defect of the skeleton. In other words, the abnormality is not in the keratinous nails which clothe the terminal phalanges but in the bones themselves, and hence the designation, ungual osteodystrophy.

This condition is not to be confused with avian brachydactyly[3,4] in which the outermost toe (D IV) is reduced in length and in homozygotes has usually no nail or only a very small one.[6] It is more comparable to the condition in man which MacArthur and McCullough[5] designate as "apical dystrophy," but in the latter the reduction of distal phalanges is more extreme.

Relation to sex. Of 298 chicks with abnormal nails, which were sexed, 152 were males, 146 were females. Because manifestation of the mutation is apparently unaffected by sex, either in expression or transmission, males and females are not considered separately in the classifications given in the accompanying tables.

Symmetry. In hereditary polydactyly, an abnormality in the fowl affecting only the inner toe, it was shown by Bond[1,2] that the left foot is affected more often than the right one. There was no evidence of this tendency in the defective toenail stock at Cornell, but the Kansas stock showed a slightly higher incidence of the expression of the character in the left foot. Among 227 birds classified in detail, the distribution of abnormalities was as follows:

	Cornell	Kansas
On both feet	34	64
On the right foot only	40	19
On the left foot only	38	32
Total	112	115

Genetic Behavior

The data in Table II show clearly that the genetic behavior of ungual osteodystrophy cannot be explained on a simple unifactorial basis. From the results of matings of defective by normal an unusual situation is to be observed regarding dominance. There is a preponder-

ance of normals in the F_1 generation, but in every one of the six matings of the type listed, some defectives were observed. It might be held that the supposedly unrelated normal stocks were not free of the factor. It is true, however, that most of the normal stocks were purebreds (White Leghorn, New Hampshire and White Wyandotte) in which the character had not been previously observed. The F_1 generation produced at Cornell showed a slightly higher incidence of defective than did the same generation of the Kansas stock. The one ratio of nine defectives to eight normals (Cornell data) is so divergent from other listed ratios as to indicate that the supposedly normal female (a New Hampshire) may have carried a gene for the defect. The difference in proportion of defectives in the two stocks may be due to the classifications being made by different observers at the two institutions and to the variability in expression of the character. Reciprocal matings of defectives by normals provided no evidence for sex-linked factors being involved.

Matings of defective by defective produced only about 50 per cent defectives among the offspring produced at each institution. If this character were due to a simple recessive which occasionally expressed itself in the F_1 generation, only defectives would have been expected from the mating of defective by defective.

A number of hypotheses might be offered to explain the irregular genetic behavior. The appearance of the character in some individuals of the F_1 generation and the failure to breed true when defectives are mated together, suggests a multiple dominant situation, in which more than one dominant gene is necessary to produce the character. The proportion of defectives in the various matings is too low to fit the hypothesis of two dominant factors for defective toenails, each dominant factor being necessary to produce the character. The simultaneous action of more than two dominant factors is required to explain the low proportion of defectives in the matings listed. In view of the difficulty of inbreeding the fowl to the degree necessary to bring about homozygosity for so many factors, such an hypothesis is difficult to establish.

An interpretation involving a multiple-recessive-factor situation is untenable because of the failure of defective by defective matings to breed true, unless one assumes a case of very low penetrance. Under such an hypothesis there would yet remain unexplained the appearance of defectives in the F_1 generation.

A lethal dominant situation might be proposed, in view of the fact that the character appears occasionally in the F_1 generation, but the excellent hatches obtained from matings of defectives by defectives fail to lend any support to this view.

Evidence that there are probably several genes necessary for manifestation of the character, some of them perhaps acting as modifiers, is provided by the following divergent ratios resulting when one affected male was mated at Cornell with several different classes of females:

	Progeny	Affected
	number	Per cent
1. × affected ♀♀	11	91
2. × mother, normal	18	67
3. × 12 related ♀♀, all normal	119	28
4. × 4 unrelated ♀♀, all normal	39	8
5. × one unrelated ♀, normal	17	53

Comparison of the data for Classes 2 and 3 above (which are not given in Table II) with the figures in Table II shows: (1) that the normal mother yielded a higher proportion of affected progeny than did the combined matings of affected birds *inter se*; and (2) that females normal in phenotype but related to the male with defective nails yielded a higher proportion of affected progeny than did unrelated females. Both of these facts indicate that genes affecting the manifestation of ungual osteodystrophy were present in the normal birds related to the male. That similar genes may occur in unrelated stock is shown by the single female in Class 5, whose progeny contained eight normal and nine affected individuals.

Linkage tests. Because this character does not segregate sharply in clearly-cut Mendelian ratios, it is not likely to be used much in tests for linkage. It happened that some of the matings at Cornell showed the condition to be independent of three mutations commonly used in linkage tests, two of which are in the six linkage groups thus far established for this species. These were crest, muffs, and duplex comb. The segregations in backcrosses were as follows:

	Parental combinations	New combinations
Tests with Crest	38	31
" " Muff	42	35
" " Duplex Comb	31	24

These tests show no evidence of linkage.

Summary

Ungual osteodystrophy was observed in birds at both Cornell University and Kansas State College. The abnormality is expressed in the loss of the toenails and terminal phalanges, and digit III is more frequently affected than any other. A small percentage of the F_1 generation individuals shows the character but matings of defective by defective produce only about 50 per cent defectives. It appears that ungual osteodystrophy is due to a complicated multiple factor situation not fully analyzed.

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TABLE I. Distribution of abnormalities of the nails in 112 affected birds at Cornell.

Affected toe	Abnormalities on: Both feet		Right foot only		Left foot only	
	Nails lacking	Nails abnormal	Nails lacking	Nails abnormal	Nails lacking	Nails abnormal
	Number	Number	Number	Number	Number	Number
D 1 only			5		3	
D I and others	1	1	1	1	1	
D II only		1			2	2
D II and others	1		1*			
D III only	9	4	15	15	12	13
D III and others	6	7	1		2*	1
D IV only	1	3	2		2	1
D IV and others					1	
Total	18	16	24	16	21	17

*Counted twice; deducted from total for column.

TABLE II. Results of matings of ungual osteodystrophy stock.

Defective by unrelated normal				Defective by defective				Defective by F_1 normal	
Cornell matings		Kansas matings		Cornell matings		Kansas matings		Kansas matings	
Normal	Defective	Normal	Defective	Normal	Defective	Normal	Defective	Normal	Defective
36	3	69	13	40	40	49	33	118	22
40	7	238	6	1	10	83	63	92	14
8	9	94	3			76	75		
						12	15		
84	19	401	22	41	50	220	186	210	36

ISOLATION OF DIPLOID AND TETRAPLOID CLONES FROM MIXOPLOID PLANTS

Of Ryegrass (*Lolium Perenne* L.), Produced by Treatment of Germinating Seeds with Colchicine*

HELEN D. HILL AND W. M. MYERS†

FOLLOWING the reports by Blakeslee[1] and Blakeslee and Avery[2] and independently, by Nebel[6,7] and Nebel and Ruttle[8] of the efficacy of colchicine in the induction of chromosomal reduplication in plants, this chemical has been used successfully with a great number of plant species. Dermen[3] has summarized early work with this chemical. The application of colchicine in aqueous solution to germinating seeds, seedlings or to the meristematic tissues of older plants has resulted in the production of sectorial or periclinal chimeras of normal and polyploid tissues, or occasionally of completely polyploid plants. According to Dermen,[3] it should be possible, by proper timing of the duration of treatment, to change a whole tissue from diploid to polyploid. Vegetative propagation of tissues from sectorial chimeras provides the possibility of securing diploid and polyploid clones which differ only in number of chromosomes and are, therefore, critical material for investigation of the effects of chromosomal reduplication.

By treatment of germinating seeds with solutions of colchicine, chromosome doubling was induced by the junior author[4] in seedlings of *Lolium perenne* L., a diploid with a $2n$ chromosome number of 14. This species is perennial. It may be increased vegetatively by isolation of single tillers, each of which arises from a single bud primordium. Hence, in the case of sectorial chimeras, it was expected that the establishment of diploid and tetraploid clones which had arisen from single seedlings could be accomplished readily. Such clones were desired for comparative investigations in cytology,[5] chemistry,[10,11] physiology and morphology.[9] In the process of isolating the diploid and tetraploid clones, it became apparent that in some cases at least, sectorial chimeras had not been induced in this species. Instead, mixoploid tissue resulted from colchicine treatment and the separation of the diploid and tetraploid tissue proved to be a more difficult problem than originally anticipated.

Material and Methods

The plants from colchicine treated seeds that were found to contain tetraploid tissue as revealed by pollen grain measurement or chromosome counts in root tips[4] were separated into single tillers and four tillers from each plant were transplanted individually to pots and grown in the greenhouse. Chromosome numbers were determined from two root tips from each resulting plant. On the basis of these determinations one plant from each original seedling from which diploid and tetraploid types were obtained was selected as the progenitor of a diploid clone and another was selected as the progenitor of a tetraploid clone. In most cases it was possible to select a plant from which both root tips had been found to be either diploid or tetraploid. Each selected plant was again separated into single tillers, which were transplanted singly into pots. Chromosome numbers were determined again

*Contribution No. 67, of the U. S. Regional Pasture Research Laboratory, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, State College, Pennsylvania, in cooperation with the northeastern States.

†Agent and Geneticist, respectively.

from two root tips from each resulting plant. In each clone, one plant was selected from which both root tips were diploid or tetraploid as desired. The selected plants and their clonal progenies were increased subsequently by single tiller isolation for two generations. At that time it became evident that at least some of the clones still contained mixtures of $2x$ and $4x$ tissue. A plan of repeated vegetative propagation was then adopted, using single tiller isolates through several generations. In each generation, the chromosome number was determined from two root tips of each plant. Selection of plants for propagation of the next generation was in every case based upon these chromosome number determinations. From five to ten plants, depending upon the number of tillers available, were established from each clone in each generation. An effort was made to keep the number of plants constant for the various clones in any generation but in some cases differences occurred due to failure of tillers to grow.

In examining the root tips the procedures described previously[4] were used with slight modifications.

Experimental Results

Among the pairs of putative diploid and tetraploid clones that were being increased, the diploid material had been lost in a few cases and the tetraploid had been lost in other cases. There remained in the first generation (first single tiller isolations from selected plants of the putative diploid and tetraploid clones) 18 pairs of clones in which some diploid and tetraploid root tips were obtained.

The results with these 18 pairs through successive generations of vegetative propagation are presented in the following outline:

I. One type of tissue not recovered.
   A. Tetraploid was lost in two pairs. The putative $4x$ clone contained predominantly $2x$ tissue with a small amount of $4x$ tissue in the first generation. It was pure diploid in the second and suceeding generations. The putative $2x$ clone was pure throughout five generations.
   B. Diploid was lost in four pairs.—In each pair, there was a small proportion of $2x$ tissue in the putative $2x$ clone through the first, second and third generations but the clone was pure $4x$ in the fourth and fifth generations. In two of the four pairs, the $4x$ clone was pure in the first and succeeding generations. In the other two pairs, there was a slight mixture of $2x$ tissue in the $4x$ clone in the first and second generations but the clones were pure $4x$ in the third, fourth and fifth generations.

II. Clones pure in the first and all subsequent generations.
   A. Both clones ($2x$ and $4x$) were pure in two pairs.
   B. Diploid clone but not the tetraploid.—Two pairs.
      1. In one pair, the $4x$ clone was found pure by the fourth and into the fifth generations.
      2. In one pair the $4x$ clone was still mixed in four sub-clones in the seventh generation.
   C. Tetraploid clone but not the diploid.—Two pairs.
      1. In one pair, the $2x$ clone was pure in the second and subsequent generations.
      2. In one pair, the $2x$ clone was pure in the fourth and fifth generations.

III. Clones pure in the second and all subsequent generations.
   A. Diploid clone but not the tetraploid.—Three pairs.
      1. In two pairs, the $4x$ clones were pure in the fourth and fifth generations.
      2. In one clone, the $4x$ was mixed through the fifth generation. In the sixth generation, two sub-clones were still mixed but two were pure.
   B. Tetraploid clone but not the diploid two pairs.
      1. In one pair, the $2x$ was mixed in the sixth generation. In the seventh generation, two sub-clones were pure and two were mixed.
      2. In one pair, four sub-clones were mixed in the seventh generation.

IV. Clones pure in the third and subsesequent generations.
   A. Diploid clone but not the tetraploid.—One pair.
      1. In this pair, the $4x$ clone was mixed in the sixth generation. In the seventh generation, one sub-clone was pure and three were mixed.

All of the clones except five were pure $2x$ or $4x$ in the fifth generation, and one of these was pure in the sixth generation. Four clones, the $2x$ from two pairs and the $4x$ from two other pairs, still showed evidence of mixture in the seventh generation. In each of these clones, three fifth-generation plants were selected for

the production of three sub-clones, in the sixth generation. For establishment of the seventh generation, four plants, from each of which both root tips were diploid or tetraploid as desired, were selected in each clone from the sub-clone in which the incidence of mixture was least as determined from frequency of $2x$ and $4x$ root tips. Despite this more intensive selection, only two sub-clones of one $2x$ clone and one sub-clone of one $4x$ clone produced exclusively $2x$ and $4x$ root tips, respectively.

Throughout this experiment there was no noticeable difference in the ease of obtaining $2x$ or $4x$ clones in pure form. Furthermore, there was no evident tendency for one type of tissue to develop at the expense of the other as has commonly been the case with sectorial chimeras in which the diploid tissue ordinarily crowds out the tetraploid. Morphologically, mixoploid plants could not be distinguished from pure diploid and tetraploid plants of the same clone, indicating that the two types of tissue did not differ markedly in morphology or growth rate. This is in agreement with comparative observations in the greenhouse of morphology and growth rates of the pure diploid and tetraploid clones.

During the course of these investigations, comparative studies were also being conducted of meiotic behavior of diploid and tetraploid plants. Frequently, inflorescences were collected from plants that were shown subsequently from root tip analysis to be mixoploid. Ordinarily, an entire inflorescence was either diploid or tetraploid, at least so far as could be determined from the microsporocytes. Occasional exceptions were encountered, however, particularly cases in which one side of the spike was tetraploid and the other diploid. In one extreme case, individual anthers were mixoploid, yielding, upon smearing, groups of diploid and other groups of tetraploid microsporocytes from a single anther.

The persistence of mixoploid tissue into the seventh generation of vegetative propagation in spite of careful selection on the basis of root tip chromosome number determinations suggests an intimate mixture of $2x$ and $4x$ cells resulting from colchicine treatment. The fact that these seven generations were preceded by four vegetative generations, in the first two of which selection was based upon chromosome numbers of root tips, provides further evidence of the extent of the mixture. This persistence of mixoploid tissue despite repeated single tiller propagation also suggests that the tiller primordium arises in this species by the differentiation of a group of cells, not all of which are descended from a single cell of the original growing point.

Summary

1. Pairs of diploid and tetraploid clones were isolated by vegetative propagation from plants of *Lolium perenne* L. following treatment with colchicine. By use of single tillers for propagation and determination of chromosome numbers of root tips in successive generations, the process of establishing pure clones was followed.

2. There was no observable tendency for either diploid or tetraploid tissue to be eliminated by the other and no noticeable difference in ease of obtaining pure diploid or tetraploid material.

3. Mixtures of $2x$ and $4x$ tissue persisted in some clones through eleven vegetative generations, indicating that there was an intimate mixture of $2x$ and $4x$ cells following colchicine treatment and that tiller primordia were produced by differentiation of a group of cells.

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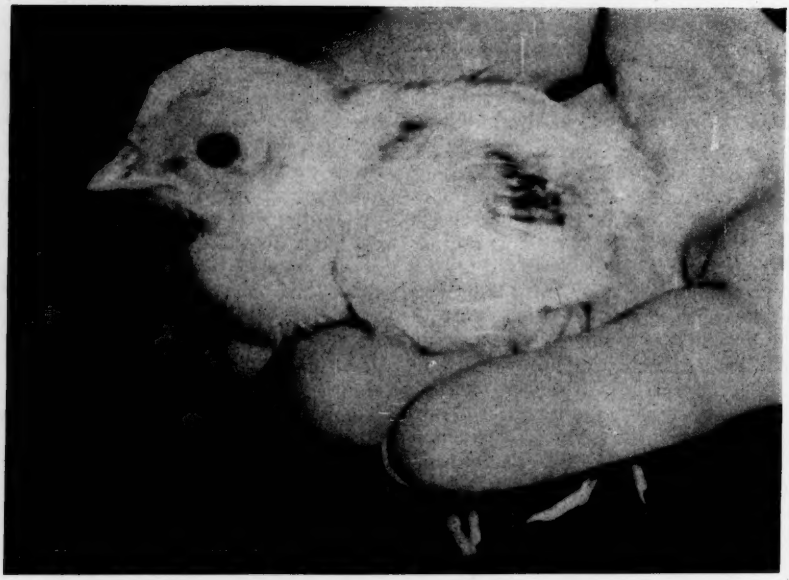

OCCURRENCE OF SPOTTED PHEASANTS

Figure 3

DURING the past few years hunters in central South Dakota have brought in an occasional pheasant showing white spots in the plumage. Such animals, although occurring very rarely, do persist in the population.

With the cooperation of the Game and Fish Commission, three such birds, one male and two females, were secured in order to test the mode of inheritance of the spotting. Such white markings appear on any region of the body and may be displayed in a limited area with only one or a few feathers affected to nearly complete loss of the wild type pigments.

A cross of two of the individuals was made, and from the ten eggs produced, eight chicks were hatched. A remarkable contrast was noted between the wild type chick and the spotted (Figure 3). The wild chick is grayish brown. Pigment is present on all parts of the body. The spotted chicks lacked the dark pigment except in a few small areas. When examined at one week of age, these chicks were nearly all uniform in the distribution of the dark areas, namely, on the wings and back. Limited brown areas were noted on the legs, also.

Since only one cross was possible, no analysis of the genetic complex of the spotting factor or factors can be made. However, as all of the offspring were uniformly spotted, one interpretation may be that the spotting is due to a recessive gene.

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INHERITANCE OF IMPERFORATE VAGINA IN THE MOUSE

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IN a colony of Aka mice kept for some years at Illinois, the condition of imperforate vagina was found occasionally. A male and female from this colony were used to develop an inbred strain, continued by successive brother-sister matings. Imperforate vagina was found in successive generations of this strain. This trait has not been found in any of the other ten strains of mice in our colony.

This condition has been found in the rat and in some strains of mice. Plagge and Lamar[3] reported that it occurred in about one in every 150 females in a colony of rats. Marx[2] stated that the abnormality sometimes appeared in his strains of black-silver mice. Gowen and Heidenthal[1] found imperforate vagina in an inbred strain and its extracted crosses of an English silver stock.

Description

The animals with this abnormality can be distinguished easily from females in which the vagina has not yet opened. In the abnormal animals, the vaginal plate is intact and there is a swelling in the perineal region, which becomes more pronounced with age. Internally, there is a small amount of connective tissue just beneath the vaginal plate and below that the vagina ends as a blind sac 1-2 mm. from the epidermis. The vagina and uterus are distended with fluid. It is viscous and varies in color from a light clear yellow to brown, the color and amount depending upon the age of the animal. The pressure of the fluid causes great distension of uterus and vagina, with a consequent bulging of the abdomen and of the perineal region. The condition is the same as in all the cases described in the literature.

The vagina can be opened surgically. A slit is made in the center of the vaginal plate and in the connective tissue beneath it and then in the blind end of the vagina. The skin is then fastened to the edges of the vagina by four interrupted sutures. Healing is slow but the opening remains patent and after the accumulated fluid has drained from the uterus and vagina, the animals copulate and reproduce normally. Seven animals were operated in this way at ages varying from 50 to 118 days. One animal died. The other six produced from two to five litters each. Matings were made after healing occurred and litters were produced within 22 to 81 days after the females were placed with males. This shows that these animals are able to reproduce normally after the vagina is opened.

Genetics

The total number of females in this strain examined for this abnormality was 135. Of this number, nine showed imperforate vagina. This is an incidence of 6.6 per cent. This rate did not change from generation to generation. In only one case did one mother produce more than one daughter with imperforate vagina; she produced two.

Imperforate animals which were treated surgically were mated to sibs when possible and to other males in the strain when necessary. These animals produced offspring, of which five females reached maturity. All of these were normal.

In outcrosses of this strain with other inbred strains, imperforate vagina has never been found.

Discussion

In comparing these data with those of Gowen and Heidenthal, it can be seen that the cases are similar. In the latter case, the total number of imperforates is 51. These were produced by 42 moth-

ers which also produced 244 normal offspring, making a total of 295. To allow for a selected group, Gowen and Heidenthal subtracted 42 cases of imperforate from the total, leaving 244 normals and 9 imperforates or a ratio of 27:1. In the present study nine imperforate animals were produced by eight females which also produced 38 normal females. In treating the data in a manner similar to the above, eight imperforates would be subtracted, leaving a total of 38 normal to 1 imperforate. With such small numbers, the ratios of 27:1 and 38:1 are not significantly different.

Gowen and Heidenthal state that the parents of the imperforate animals are both heterozygous because they produced imperforates. It would not seem likely that such matings would be found in an inbred strain, particularly matings in which both individuals are heterozygous for each of two factors, as is suggested by the above authors.

The ratio of 27:1 is too low for two factors. A possible explanation given by Gowen and Heidenthal is that some individuals with very small vaginal openings should be considered as genetically similar to those with imperforate vagina. In the present study, the size of the vaginal orifice was measured at the time it opened in 53 animals. The size varied from 0.3 to 3.1 mm. with a mean of 1.55 ± .20. In another inbred strain, the C57 Black, in which imperforate vagina has never occurred, the size of the opening varied from 0.4 to 1.9 mm., with a mean of .80 ± .03. This is a much smaller opening in general than that found in our Aka strain. This would suggest that a small vaginal opening has no connection with imperforate vagina.

The rate of occurrence of imperforate vagina in the present study and in the study by Gowen and Heidenthal is too low to be accounted for by two independent factors. The fact that there does not seem to be a change in frequency with successive generations of brother-sister matings or in matings of operated imperforates would indicate that the inheritance is not a simple Mendelian segregation. It seems probable that the condition is one of those cases in which the trait occurs sporadically within a strain, for which no definite gene differences can be assigned. A somewhat similar situation was reported by Wright,[4] where otocephalic individuals appeared irregularly in certain highly inbred strains of guinea pigs.

Summary

Imperforate vagina was found in 9 out of 135 females in an inbred strain of mice. The percentage incidence (6.6 per cent) did not change with successive generations of brother-sister matings. Operated imperforate females produced five normal females and no imperforates. Small size of vaginal orifice has no connection with this abnormality.

The trait appears to be a strain characteristic which has a certain low frequency of expression.

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CHINESE SWINE AND THEIR PERFORMANCE

Compared With Modern and Crosses Between Chinese and Modern Breeds

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CHINESE swine have made a considerable contribution to the development of many of the breeds now utilized in the United States. There is much debate concerning the exact origin of these breeds, but most authors accept Smith's[17] conclusion that, while most breeds in the United States are of American origin, they descended wholly from importations made during early periods of American history and extensive additions from 1800 to 1850. Smith considers that this 1800-1850 influx included the most important foundation stock for the production of the modern breeds. It came principally from European countries and West Africa, but much of the ancestry of this stock came originally from China and other countries of southeastern Asia. Harris,[3] Coburn,[2] Layley and Malden,[13] Smith,[17] and others agree that Chinese and other southeastern Asiatic pigs were brought to Great Britain for crossing with the large-framed, coarse native pigs, in order to improve their quality and ability to fatten.

Owing to the importance of Chinese swine in the development of many breeds now produced in the United States, it is of interest to compare the two groups in conformation and performance. The objects of this paper are: (1) to present a brief description of Chinese swine types, and (2) to present a résumé of data, recently accumulated in China, on the performance of certain types of Chinese swine and of crosses between these and some modern American and English breeds, thus making the material generally available to breeders and scientists interested in swine improvement.

Types of Chinese Swine

Chinese swine may be divided roughly into two main classes, the North China and South China types. Little is known of the history of either of these but it seems probable that they originated from somewhat different wild strains. Allen[1] states that the number of recognizable races of wild pig in China and Mongolia can be determined only by further study of a large series of specimens. He reviews the available information and gives a tentative classification as follows: *Sus scrofa raddeana* in portions of Manchuria and outer Mongolia; *Sus scrofa moupinensis* in Hopei, Chantung, Shansi, Shensi, Honan, southern Kansu and much of Szechwan; and *Sus scrofa chirodonta* in Hupeh, Anhwei and the other portions of China lying south and east of these provinces. The rough dividing line between the two latter sub-species is approximately the same as the boundary between the North and South China types, shown in Figure 4. However, Allen[1] points out that these two wild types differ only slightly. There is not sufficient information available to judge whether the existing domesticated swine are directly decended from wild types indigenous to the same areas.

The North-China hogs are long, lean

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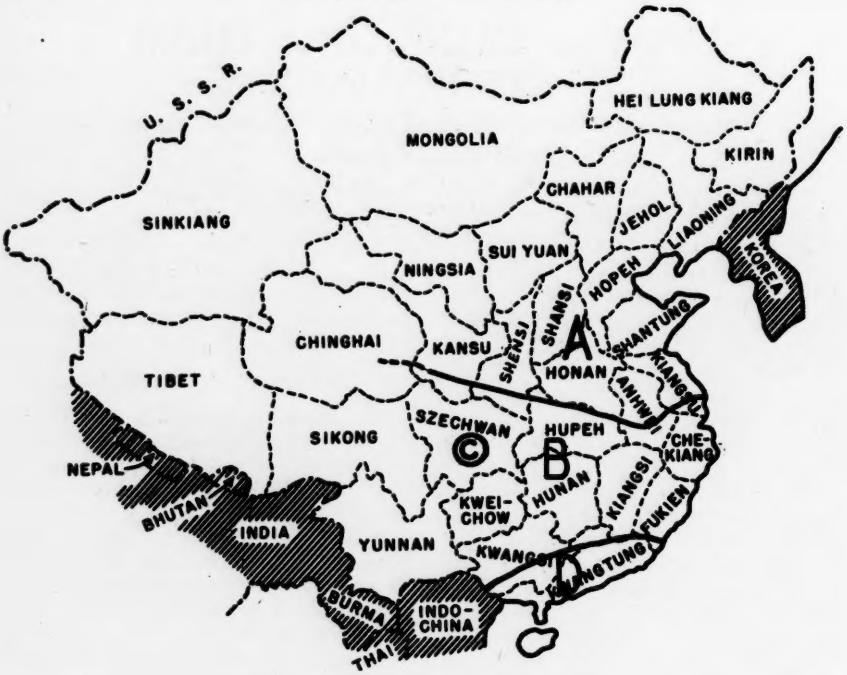


DISTRIBUTION OF SWINE TYPES

Figure 4

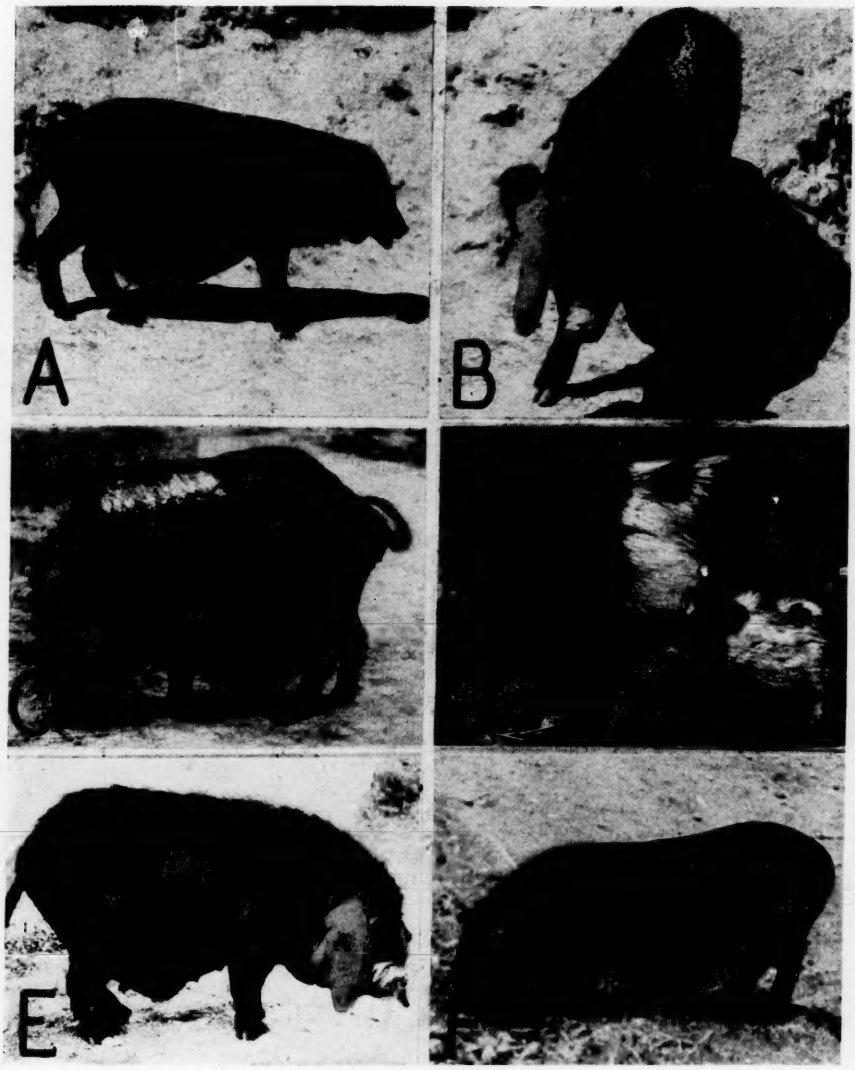
Map showing the approximate dividing line between areas in which North and South China types of swine are found, and approximate location of two South China sub-types. *A*—North China swine; *B*—South China swine; *C*—South China Yungchang swine; *D*—South China Cantonese swine.

animals with long narrow heads, rather straight faces and large ears. Black is the predominating color and white markings are rarely seen. The back is narrow and usually is straight or slightly sagging. The hams are very light. Wrinkles on the face are usually parallel and run along the long axis of the face. The rate of growth is relatively slow, but sows are reported to be quite prolific.

The South-China pigs are shorter, broader backed and more rotund. The hams are somewhat larger, although not as plump as those found on most American and English breeds. The back usually sags more than in North-China pigs. The head is short and rather wide, the face somewhat dished. Wrinkles on the face may be tortuous and tend to run at right angles to the long axis of the face. There is considerable variation in color in different regions, ranging from solid black to nearly white, and with some red or reddish brown animals. The sows are reported to be less prolific than those of the North-China type, and the pigs grow more rapidly, but there is considerable variation among the South-China pigs. The hair is somewhat softer than on the North-China pigs.

The approximate dividing line between the two types is shown on the map in Figure 4. There is some intermingling of the types along this tentative boundary, of course.

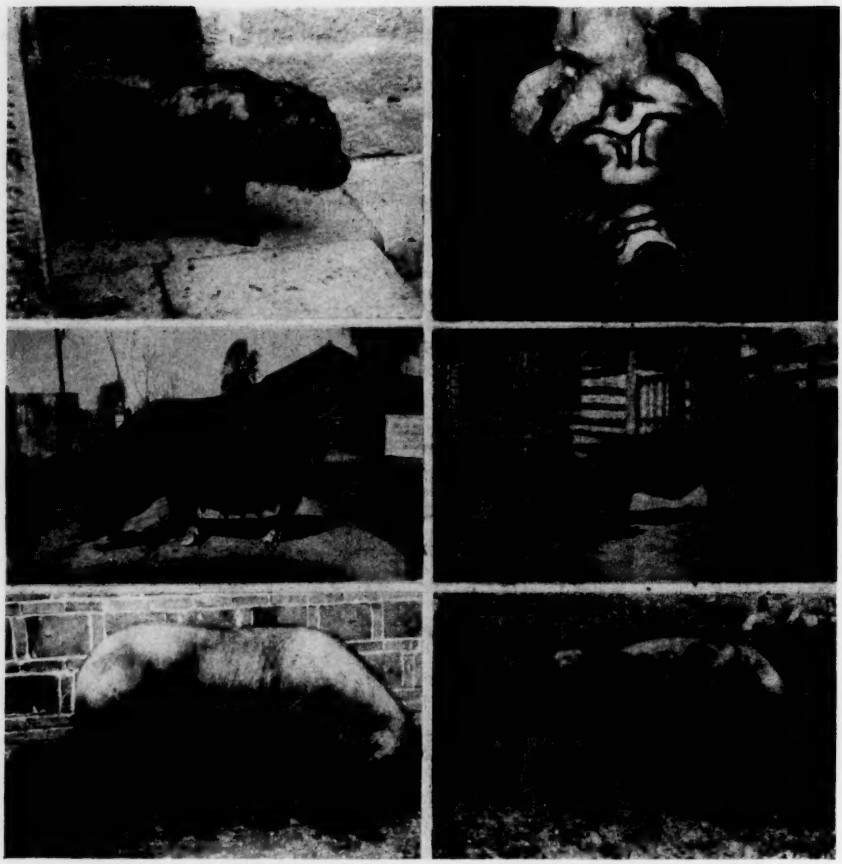
The hogs of North China may be divided into two classes, a large and a small type. There are gradations between these two extremes, and the de-



NORTH CHINA SWINE

Figure 5

A—Sow, photographed in Chinghai. This is the type commonly seen in Chinghai and Kansu. *B*—Front view of sow in *A*. *C*—Litter-mate sow and boar of Kansu, age seven months. Sow in foreground was 11½ inches high at the top of the shoulder and was due to farrow in about 3 weeks. *D*—Small type of pig found in limited numbers in Kansu (photographed by F. P. Sha, Chinese Ministry of Agriculture). *E*—Mature boar of the larger type found in Kansu (photographed by F. P. Sha). *F*—Pig of the type found in the vicinity of Chiangpei, Kiangsu.



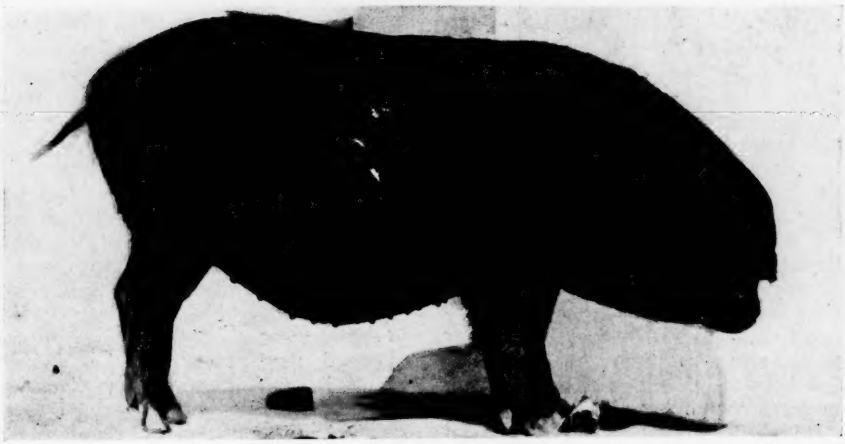
SOUTH CHINA BLACK HOGS

Figure 6

A—Small type black boar of Szechwan province. *B*—View of head of boar in *A*. *C*—Large type sow of the type found in the vicinity of Neichiang, Szechwan, age 14 months (photographed by S. Y. Chang, Szechwan National University). *D*—Pigs of the same types as the sow in *C*. *E*—Sow of the type found in Kweichow. Red and brown are interspersed with the more common black ones in this area. *F*—Fattening hog of the same type as the sow in *E*.

scriptive terms, large, medium and small, are sometimes used in describing the variations in type.

Black strains predominate in many regions of South China, but black-and-white strains, such as the Yungchang and Cantonese, are typical of certain localities. Yungchang hogs are found principally in Yungchang hsien (county) and parts of Lungchang and Luchow hsiens to the south and west of Yungchang (see Figure 4). These hogs are white over most of the body and have black spots around the eyes, varying from narrow circles to large spots that include much of the head and ears. They are sometimes referred to as "bi-spectacled whites." Some entirely white or nearly all white animals are seen. Adjacent to the home of the Yungchang



NORTH CHINA SOW
Figure 7

Sow of the Shantung province (photograph furnished by F. J. Rossiter, Office of Foreign Agricultural Relations, U. S. Dept. of Agriculture).

hog there is a region where many black-and-white hogs are found, owing to crossing of the Yungchang with black strains.

Cantonese hogs are found in the vicinity of that city and adjacent regions. There are not sufficient data available to delimit their range accurately but the approximate area is shown in Figure 4. The predominating color is black-and-white, with considerable variation in the relative amounts of the two colors. These hogs have been described by Levine,[14] who states that colors range from nearly white to black, or black with white points. In some localities the ears are large and pendulant, in others they are small and erect. Both types are sometimes found in the same community. It seems probable then that this is the area from which most animals were exported from China for use in swine breeding in Great Britain.

Black hogs predominate in most other regions of South China, Although some black and white pigs are found in Chekiang, Kwangsi and Hunan provinces, and animals with white markings are seen occasionally in other areas. Many of those in Chekiang have a tendency toward "white belting," being white with black over the head and rear quarters. The natives refer to these as "two ends black pigs." Red or reddish-brown animals are frequently seen among the black strains, especially in the mountainous regions of Kweichow, Szechwan and Sikong and similar regions to the north and south of this area. There is considerable variation in type within the black strains, even in adjacent areas. For example, the hogs around Neichiang, Szechwan province, are larger, less chuffy and somewhat later maturing than those around Chengtu in the same province. Hogs in the mountainous regions tend to be somewhat leaner in appearance than those of the more fertile lowland areas, but they may reflect differences in environment rather than in heredity.

Pork is a favored article in the diet of the Chinese and hogs are raised extensively in most areas occupied by them. Chinese emigrants have taken hogs into Manchuria, mostly from Shantung, and these are described in the Japan-Manchukuo yearbooks (see Wang[20]) as being black and of three types, large, medium, and small. These

appear to be of the North-China type already described.

Many regions in Mongolia, Tibet, much of Chinghai and Sikong and parts of Sinkiang have little feed that is suitable for hogs, hence the swine population is small. According to Johnson[12] the pigs in Sikong are small, and for the most part exist on vegetation. They are much smaller and have shorter ears than those of the Chengtu area, east of Sikong, in Szechwan. Chengtu is the chief city through which trade passes to and from Sikong. Mohammedans of the northwestern areas do not eat pork, so few hogs are raised in areas where this group predominates.

The limited or total lack of available information concerning the swine in many localities in China, renders any description of types necessarily incomplete. However, the foregoing description and the photographs in Figures 5 to 9 will indicate main types and some of the variations within these types. Other variations within types and details of subtypes can only be filled in as more information becomes available.

Performance of Chinese, Modern × Chinese, and Modern Breeds of Swine

The work reviewed below was conducted at National Central University, and was largely financed by a grant from the Rockefeller Foundation in connection with its rural reconstruction program in China. From February, 1936 to October, 1937 the work was conducted at Nanking. Owing to the Japanese invasion, the staff and part of the herd were moved to Chungking and then to Chengtu. After the move to Chengtu, the Szechwan provincial Government cooperated with National Central University in the work until it was concluded in 1941.

Owing to wartime conditions some details of the data were lost, the work is inadequate in some respects, and not as complete as could be desired in other respects. Nevertheless, these appear to be the only data of their kind in existence and should be of considerable interest to swine breeders. Much of the information has been published in Chinese (see Literature Citations, Nos. 4 to 11, and 18), but a summarization of data and conclusions is given here to make the findings generally available to workers who cannot utilize the original material.

The Chinese swine used at Nanking were of the North-China type, with the exception of a few from Chekiang that were intermediate, while those at Chengtu were of the South-China type. Rations used at Nanking were comparable to those commonly fed under conditions of good management in the United States, but tankage was not available at Chengtu so only vegetable protein was supplied.

A survey of levels of fertility on farms in four sections of Szechwan, including the Chengtu, Yungchang and Neichiang areas, revealed that litter size varied from 8.4 to 9.1 in the four areas and averaged 8.8. In 31 sows native to the Chiangpei area of Kiangsu, an average litter size of 13.9 was observed. Tong[19] cites an exceptional case of a North-China black sow, kept at Minghsien College, that had 32 teats and produced 25 live pigs in one litter. Levine[14] states that in the Canton area a sow is supposed to be able to nurse at least ten pigs, which seems to be the average for the region, although as many as 15 are frequently seen with one sow. Thus it appears that the Cantonese sows are more prolific than those in some other parts of South China.

Chinese pigs are reputed to develop sexually more rapidly than modern breeds. Chinese animal husbandry workers cite instances of gilts being bred by litter-mate boars before 60 days of age. Gilts are usually bred when about five months old, but earlier breedings are common and Chinese workers say that it is not unusual to find gilts farrowing at about six months of age. This is in marked contrast to the findings of Phillips and Zeller[15] with the Poland China breed, in which spermatozoa were first observed in the testes at 20 weeks of age, and large- and small-type gilts exhibited first estrus at 198.7 and 207.8

days, respectively. Hsu and Peng[10] studied ten gilts of the type found in the vicinity of Neichiang, Szechwan. Five were on a standard and five on a typical farm ration; and the average ages of first estrus were 88.6 and 108 days, respectively. First estrus averaged 5.2 and 5.8 days in length and later estrous periods were shorter, the average for the groups varying between 2.0 and 3.0 days, after the second estrus. These gilts were checked for estrus twice daily.

Pigs from Chiangpei in Kiangsu province and Chinhua in Chekiang were compared and both types were about equal in rate of growth. The Chinhua pigs had more subcutaneous and less kidney fat than those from Chiangpei. These regions are on the borderline between the North and South China types. The Chinhua pigs, owing to the thicker back fat, appear to be more like the South-China type than those of Chiangpei, and the black and white markings indicate that they may be intermediate between the North-China and a black-and-white strain of the South-China type.

Relatively few data are available concerning the feed-lot performance of the native pigs. Some of these data will be summarized along with the data on crosses with American and English breeds. Some data, not involved in these studies, are summarized here.

Four pens of pigs purchased in the Chiangpei, Kiangsu area were fed for varying periods and the results are summarized in Table I.

A direct comparison was not made with pigs from the vicinity of Chinhua, Chekiang, but six of the latter type were fed in an experiment to compare growth rates of pigs confined in sunlight and in a dark room. This work was stimulated by the common practice among Chinese farmers of confining their pigs in dark quarters. The data are summarized in Table II, and indicate that pigs grow more rapidly in sunlight.

A comparison of the performance of three strains of Szechwan pigs by Hsu and Chiang[7] showed that the types differed in time of fattening and the weight when it was most profitable to market them. Small, black pigs from Chengtu were at their optimum condition at 180 catties* (about 198 pounds), larger black pigs from Neichiang at 250 catties (about 275 pounds) and Yungchang pigs at 210 catties (about 231 pounds). At lower weights they were not fat enough to please the public demand for a fat carcass, and if fed longer the gains became too expensive. Some data obtained on animals being slaughtered in the normal course of business in the Chengtu, Neichiang and Yungchang markets are summarized in Table III.

Hsu and Peng[9] studied the performance of six sows from the Neichiang, Szechwan, and eight from the Yungchang, Szechwan area, including performance of the sows and their progeny. The data are summarized in Table IV. The pigs were weaned at ten weeks and put on feed at 13 weeks of age. Average- or medium-size pigs in each litter were selected for feeding, the extra large or small ones being discarded. The number of pigs farrowed is much higher than that cited earlier as the average for farm sows of this type. These sows were especially selected and were maintained under much better conditions than are commonly found on farms. The Neichiang pigs grew at a more rapid rate over the entire feeding period but the greatest difference occurred after the pigs reached 220 catties. The Neichiang pigs made more efficient gains and the difference of 67.6 catties in feed required per 100 catties gain was statistically significant. The carcasses of the Yungchang pigs were somewhat fatter, owing to slower growth and a longer fattening period.

Levine[14] reports that 12 hogs fed at the Canton Christian College made an average daily gain, at six months of age, of about 0.65 pounds a day on full feed, and that these pigs usually weigh between 200 and 250 pounds at one year.

*This is the new catty, equal to ½ kilo or about 1.1 lbs. The old catty was equal to about 1.3 lbs.

The average dressing per cent of 32 hogs was 72.5.

The studies in which native pigs were compared with modern and modern × native crossbreds are summarized below. Owing to the different native types used in work at Nanking and Chengtu, the work at the two locations is reviewed separately.

Work at Nanking

The modern breeds involved in this work were Berkshire, Chester White, Duroc Jersey, Hampshire and Large Yorkshire. The Duroc Jersey and Yorkshire hogs were rather large and rangy, while the hogs of the other four breeds were of a smaller, more compact type. Native pigs were of the North-China type and came from the vicinity of Chiangpei, Kiangsu. Numbers were limited and the modern breeds were grouped together for some comparisons with the native pigs. Loss of original records, owing to wartime conditions, make it impossible to indicate the proportions of the various modern breds in some of these cases. All pigs were given comparable treatment, and the management and feeding were as near to generally-accepted American standards as the working conditions permitted. The ration generally used included corn, tankage, soybean oil meal, bone meal and salt. In feeding trials with fattening hogs, the protein content of the ration ranged from about 16.6 percent at the beginning to about 12.9 per cent at the end.

The duration of gestation was similar in all groups. The average length of 32 gestations in modern sows was 115.8 ± 0.51 days; in 21 gestations in native sows it was 115.1 ± 0.39; and in five F_1 sows mated to modern boars, it averaged 113.6 ± 0.87.

The interval between deliveries of individual pigs at parturition in the above modern and native sows averaged 23.2 ± 4.18 and 19.7 ± 2.69 minutes, respectively, and the difference was not statistically significant.

Pigs from sows of modern breeds were somewhat heavier than those from native sows at birth. The average weight of 334 pigs of modern breeds was 2.06 ± 0.04 catties. Eighty-eight native pigs averaged 1.61 ± 0.04 and 314 crossbred pigs out of native sows averaged 1.69 ± 0.03. Differences between various groups are shown below, with their standard errors:

Modern — Native	0.45 ± 0.057 catties
Modern — F_1	.36 ± 0.049 "
F_1 — Native	.08 ± 0.049 "

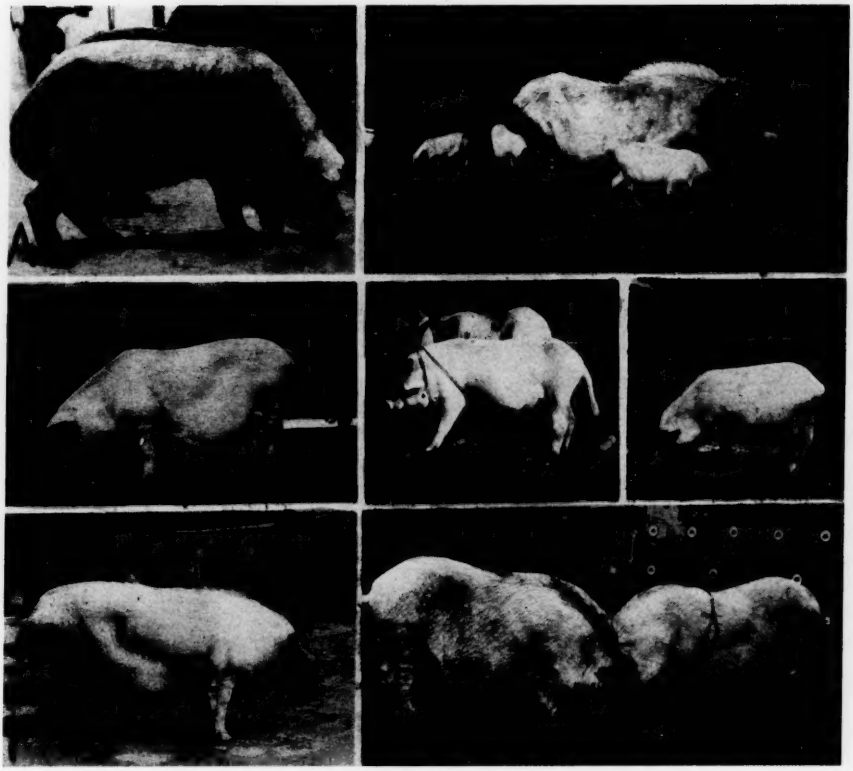
The native sows were smaller and had larger litters than the modern sows, which at least partially accounts for their pigs being lighter.

The 462 male pigs born in this work averaged 1.86 and the 346 female pigs 1.84 catties at birth and the difference was not significant. The sex ratio was 133.5.

The Chinese sows are reputed to be good mothers and the available data bear out this belief. Data on survival to weaning (at ten weeks of age) are summarized in Table V.

The changes in weight of the sows owing to reproduction indicate that the loss is greater in the native sows. Sixteen modern sows averaged 317 catties before parturition. They lost an average of 40.8 catties during parturition, and 38.4 during 10-weeks lactation, a total of 79.2. Eighteen native sows averaged 285.7 catties before parturition, lost 47.1 and 46.0 catties, respectively, at parturition and during lactation, or a total of 93.1.

The Chinese sows, being smaller, consumed less feed than the modern sows during lactation. During 1936 the average daily feed consumption of four sows of each type was 9.93 and 12.1 catties per head. During 1937 the sows had access to green alfalfa and the consumption of concentrates was somewhat lower, averaging 8.84 catties daily for 12 modern sows and 7.73 for 11 native sows. An interesting comparison was made of the combined feed consumption of the sows and their pigs during the nursing period. The data are summarized in Table VI. The difference in efficiency of production, thus measured, was 94.9 ± 21.29 catties. The native sows were



"BI-SPECTACLED WHITE" HOGS

Figure 8

This curious pattern is found in Yungchang, South China. *A*—Boar, age two years. *B*—Sow and litter. *C*—Sow, age two years and ten months (photograph by S. Y. Chang). *D*—Weanling or "tethering" pigs. *E*—Fattening hog, age six months, estimated weight 75 pounds. *F*—Fat hog. *G*—Fat hogs nearly ready for slaughter; age unknown, but had been in fattening pen four months and weighed an estimated 325 to 350 pounds.

raising hybrid pigs, however; hence there is not a direct comparison of the modern and native types.

Data on performance of various breeds and crosses during the feeding period are summarized in Tables VII, VIII and IX. Carcass data were obtained on some of these groups and certain interesting items from these data are summarized in Tables VIII and IX.

The rate of growth in the native pigs was slower than that in either the modern purebred or the modern × Chinese groups that were fed. Native pigs required about 281 days from birth, on the average, to reach market weight (about 180 catties), while crossbred pigs (sired by modern boars, and out of native sows) required about 208 days, or 73 days less to reach the same weight. Differences in efficiency of feed utilization are not nearly so marked. In the groups for which data are summarized in Table VIII, the two native lots required the largest amounts of feed per unit gain, while in the groups summarized in Table IX, the two native groups fall within the range of the crossbred groups.

The dressing percentages available for various groups, including some animals in addition to those listed in previous tables, are summarized in Table X. The native groups fall within the range of the purebreds and crossbreds.

Some definite differences appear in the mode of fat deposition. The data for caul and kidney fats are summarized in Table XI. All the differences listed in the lower half of this table are significent and indicate that the native pigs put on relatively more caul and kidney fat than the modern breeds, while the crossbreds are intermediate in this respect. The few pigs from Chinhua, Chekiang that were studied were similar to the crossbreds, caul fat averaging 4.88 $\pm$ 0.73 catties and kidney fat 5.10 $\pm$ 0.70 catties, but they were slaughtered at somewhat lighter weights than the other animals, and at equal weights would have been nearer to the other native pigs.

Back fat was significantly thicker in native and crossbred pigs than in the modern group, but the crossbred and native pigs did not differ significantly. The data are summarized in Table XII. The few Chinhua, Chekiang pigs, which were slaughtered at somewhat lighter weights, had a thickness of back fat of 5.66 $\pm$ 0.32 cm., or nearly as thick as that of the crossbreds and Chiangpei, Kiangsu natives.

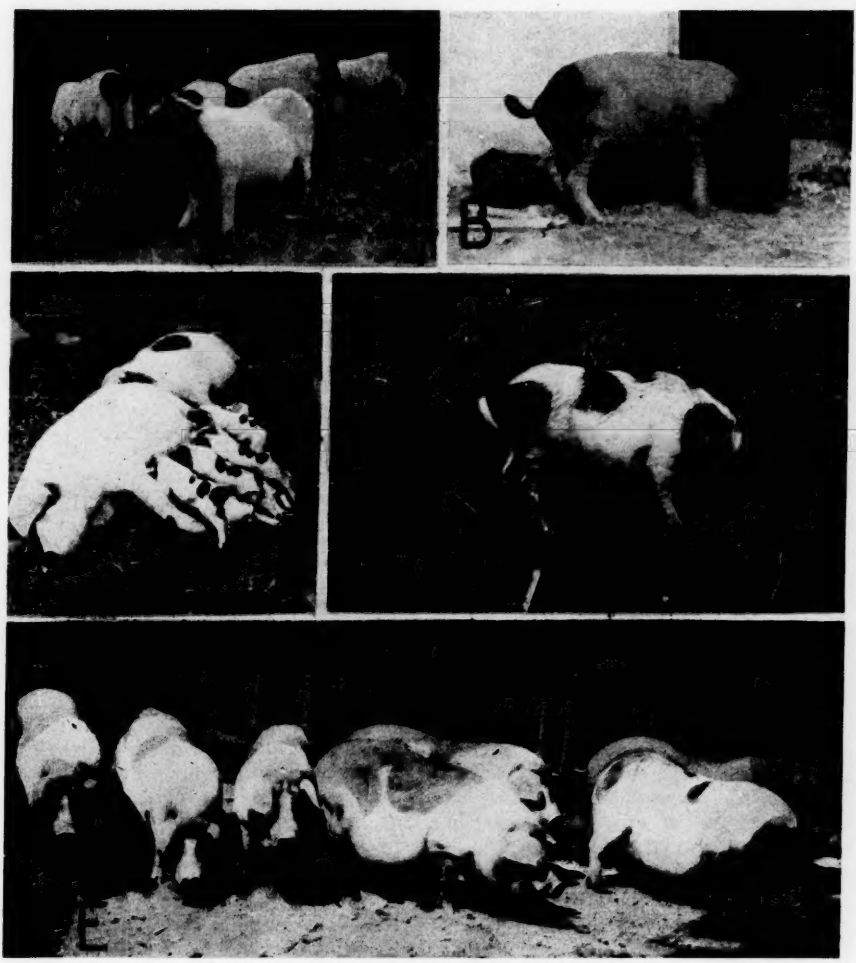
Thickness of skin was greatest in the native, lowest in the modern, and intermediate in the crossbred pigs. The data are summarized in Table XII. In the Chinhua, Chekiang pigs thickness of skin was similar to the modern pigs, averaging 0.2 cm.

In an effort to determine fundamental reasons for differences in growth rate between modern and native pigs, certain organs were weighed or measured. The heart and liver were heaviest in the crossbreds and lightest in the natives. The means and differences are shown in Table XIII. The small intestine was longest in the modern breeds, and shortest in the native. The means and differences are shown in Table XIII. Lengths of the large intestine were similar in the various groups and the small differences were not significant.

Work in Chengtu

The native swine used in this work were of two types, the rather large black pigs found in the vicinity of Neichiang, Szechwan and the "bi-spectacled" white pigs typical of the Yungchang, Szechwan area. The rations used in feeding trials were balanced according to the same standard used at Nanking, but tankage was not available and all the protein was of plant origin. Berkshire, Chester White, Yorkshire, and Poland China boars were used to sire crossbred pigs, and the data on performance of these and native pigs are summarized in Table XIV. All the crossbred groups grew at a more rapid rate and their gains were somewhat more efficient. No material differences appear between the natives and the crossbreds in length of the small intestine and in deposition of fat, the native litters falling between the extremes observed in crossbreds in most of these measures, the only exceptions being caul and kidney fat, in which the Yungchang native pigs showed the highest levels of any of the groups.

Bristles have been an important source of income. It is not possible to predict the future importance of bristles, but much depends on developments in the synthetic bristle industry. Native Chinese hogs have longer and stiffer bristles than the modern hogs of the United States and the methods of management result in a much longer period for bristle growth before the hogs are slaughtered. Under prewar conditions white bristles were more valuable than black and the Yungchang hogs were one of the chief sources of white bristles. Data on bristle length at the end of the feeding period were obtained on the animals for which performance data are presented in Table XIV. Data on bristle length are summarized in the same table. They are inconclusive, owing to small numbers. The crossbreds compared favorably and in one case exceeded the native animals in length. However, bristles on



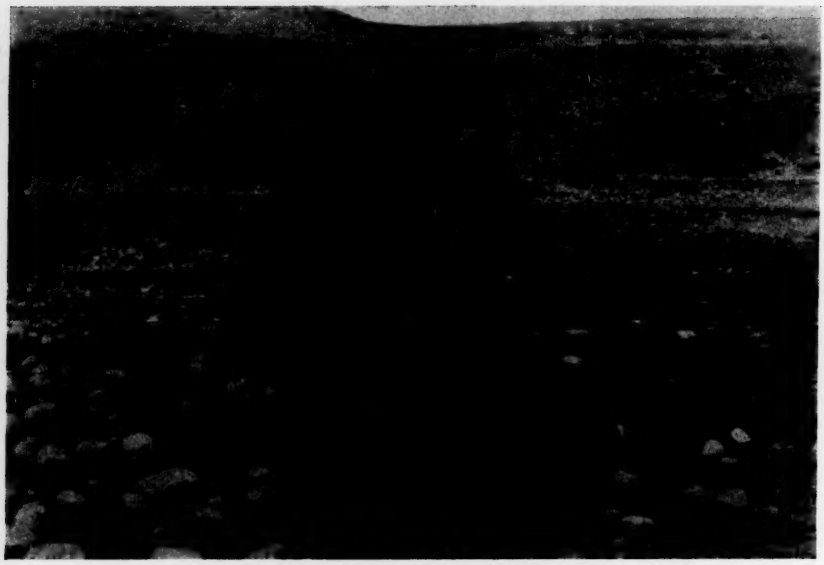
SOUTH CHINA BLACK-AND-WHITE HOGS

Figure 9

A and *B*—Pigs of a type found in vicinity of Chinhua, Chekiang. *C*—Sow and litter of a type found in vicinity of Nancheng, Kiangsi (photographed by F. J. Rossiter, Office of Foreign Agricultural Relations, U.S.D.A.). *D*—Spotted pig of a type found in limited numbers among the black pigs of Kweichow. *E*—Cantonese fat hogs (after Levine[14]).

the crossbreds were not as stiff as those on the native animals.

In the various feeding trials summarized in preceding portions of this paper, the animals were maintained under experiment-station conditions, with management and feeding practices as comparable with those used in the United States as the circumstances permitted. In Szechwan, where this work was done, the pigs are weaned at from one to two months of age and the majority of them are sold to poor farmers who feed them scantily for two to five months, then resell them as medium-sized feeders. These medium-sized feeders are fed,



HOGS FROM THE SIKONG HIGHLANDS

Figure 10

Hogs of the type found in the highlands of Sikong province. They exist largely on grass and other roughage. Color is black. The face is long and the ears are quite small. (Photograph by R. G. Johnson, Oregon State College.)

mostly on roughage and farm refuse to be converted into manure, after which they are sold again as large feeders. The medium-sized feeders are handled by small tenant farmers and others who desire them as a means of providing manure for their land. They sell these as large feeders to the well-to-do farmers, and to proprietors of mills, oil presses, breweries, etc., to be fed on fattening rations for two or three months, after which they go to market as slaughter hogs. The total feeding period, from weaning to slaughter, may vary from six months to as much as two years. There are many variations of the above pattern, but it serves to illustrate the essential pattern of swine production, in which animals are "stretched up" largely on roughage and under otherwise poor conditions of environment, after which they are fattened for a brief period on relatively good-quality feeds. Available experimental evidence[16] would indicate that this procedure tends to produce animals with relatively under-developed muscles and a high proportion of fat. A limited test was made of the performance of some native, modern purebred and crossbred pigs under experiment station conditions until they weighed from approximately 100 to 150 pounds. They were then distributed to farmers to be fed in their own way. Weights were taken at intervals of four weeks, until the pigs were approximately one year old. The data are summarized in Table XV. Obviously, the numbers are too limited to permit definite conclusions. Study of the data does not indicate definite superiority of any of the three general groups (native, modern purebred and crossbred) used in this study. Much further work is required to determine the adaptability to Chinese farm conditions of the modern breeds and crosses between these and native types.

Table 1. Performance of four pens (4 pigs per pen) of North-China (Chiangwei) pigs.

Item compared	Pen Number 1	2	3	4
Days on feed	97	74	92	126.0
Initial weight*	87.8	85.2	84.5	88.8
Final weight	180.5	152.0	179.4	179.4
Avg. daily gain	0.88	0.90	1.03	0.69
Feed per 100 cattles gain	444.7	466.0	470.2	592.2
Dressing percent (warm)	68.8	70.2	74.1	73.4
Back fat, cm.**	3.05	4.38	5.0	5.12

* In cattles
** Measured at top of shoulder

Table 2. Performance of Chekiang pigs in sunlight and in dark quarters (5 pigs in each lot).

Item compared	Conditions Sunlight	Darkness**
Initial weight*	38.2	36.7
Days on feed	133	135
Final weight	149.7	139.2
Avg. daily gain	0.84	0.7
Feed per 100 cattles gain	400.6	442.6
Dressing percent	72.3	71.9
Back fat, cm.	5.60	5.85

* In cattles
** Only 2 pigs finished this trial

Table 3. Summary of slaughter data in three Szechwan markets.

Items compared	Chengtu March	Chengtu April	Chengtu May	Meichiang Winter	Meichiang Spring	Tungchang Winter	Tungchang Spring
No. of hogs	19	35	30	37	35	26	16
Live weight*	169.7	181.5	173.2	237.8	272.4	231.0	196.2
Dressing percent	72.2	66.1	68.2	78.7	79.0	75.4	72.4
Caul fat (percent)	1.79	1.71	1.98	4.80	5.20	4.73	4.09
Kidney fat (percent)	2.84	2.78	3.05	5.02	5.87	5.33	4.23
Back fat (cm.)	5.73	5.67	5.56	6.87	7.31	8.13	7.65
Length of bristles (cm.)**	9.11	8.81	8.04	12.39	11.89	13.44	11.79

* In cattles. Catty= 1/2 kilo, or about 1.1 pound.
** Bristles on back.

Table 4. Average performance of 6 Meichiang and 6 Tungchang sows and their progeny (four pigs per litter were fed).

Items compared	Breeding of sows and pigs Meichiang	Tungchang
Pigs farrowed	12.7	12.0
Pigs weaned	10.3	8.5
Avg. birth weight (cattles)	1.5	1.5
Avg. weaning weight	26.0	24.6
Avg. initial weight in feedlot	31.0	27.8
Avg. final weight	243.7	240.2
Avg. final age (days)	331.3	387.0
Avg. daily gain	0.89	0.72
Feed per 100 cattles gain	506.7	574.3

Table 5. Comparison of litter size in modern and North-China native sows.

Type of sow	No. of litters	Number of pigs Born	And 1st week	Weaned	Percent weaned	No weaned per litter
Modern	26	262	201	179	68.5	6.88
Native	22	307	259	236	76.9	10.73

Table 6. Comparison of feed utilization during lactation in modern and North-China native sows and their litters.

Type of sow	No. of litters	Gain per litter (cattles)	Feed per 100 cattles gain (in cattles)
Modern	16	233.3	417.2 ± 18.67
Native	15	277.4	322.3 ± 10.22

Table 7. Performance of modern purebred and modern x native North-China crosses, 1936 data. Pigs were put on feed at 13 weeks, or 3 weeks after weaning. Four pigs per lot.

Items compared	Breeding and sex of pigs Hampshire barrow	Berkshire barrow	Berkshire female	Hampshire x native barrow	Hampshire x native female	Berkshire x native barrow	Berkshire x native female	Poland China x native barrow	Poland China x native female	Yorkshire x native barrow
Initial weight (cattles)	33.3	43.4	39.3	33.6	33.4	43.2	43.0	32.4	28.0	33.8
Days on feed	140	112	126	112	154	112	112	140	154	112
Avg. daily gain	1.00	1.25	1.12	1.35	0.98	1.21	1.15	1.07	1.01	1.36
Feed per 100 cattles gain	390.6	360.1	361.6	341.9	401.2	382.0	374.7	399.0	394.6	338.4

Table 8. Performance of modern purebred, native, modern crossbreds and modern x native crosses, 1937 data. Four pigs per litter were put on feed at 13 weeks or 3 weeks after weaning.

Items compared	Breeding and sex of pigs Hampshire barrow	Hampshire female	Hampshire female	Native barrow	Native spayed female	Hampshire x Poland China female	Yorkshire x native barrow	Yorkshire x native female	Chester White x native barrow & female
Initial weight (cattles)	42.0	45.3	44.8	20.5	16.5	32.8	39.3	39.1	36.7
Days on feed	139	133	135	220	268	123	134	130	117
Final weight	180.0	187.3	174.8	177.4	175.2	183.1	180.8	186.4	181.4
Avg. daily gain	0.99	0.93	0.98	0.71	0.59	1.22	1.06	1.13	1.07
Feed per 100 cattles gain	455.5	462.5	459.2	484.6	540.3	403.3	415.2	352.8	465.6
No. slaughtered	4	3	4	2	4	4	4	4	4
Dressing percent*	72.3	71.8	70.9	72.4	74.5	74.0	71.8	69.5	76.9
Length of small intestine (Chinese feet) **	65.1	53.5	61.0	51.4	48.5	56.5	54.9	54.5	55.1
Caul fat, percent*	1.75	2.00	1.87	3.73	4.53	1.68	2.48	1.92	2.43
Kidney fat, percent *	1.73	2.09	1.57	3.94	5.54	1.94	2.45	2.14	2.40
Back fat (cm.) ✣	5.12	5.20	4.10	4.65	4.99	5.12	6.00	5.83	5.88

* Percent of live weight
** Chinese foot = 1/3 meter
✣ At top of shoulder

Table 9. Performance of native and modern x native crossbreds. Pigs were weaned at 10 and put on feed at 13 weeks. Eight pigs per lot. Barrows and gilts are included in all lots. Females were spayed in the native lots only.

Items compared	Breeding of pigs							
	Native	Native	Hampshire x native	Berkshire x native	Berkshire x native	Yorkshire x native	Duroc Jersey x native	Duroc Jersey x native
Initial weight (cattles)	28.9	30.8	41.3	42.4	42.2	38.2	53.1	40.4
Days on feed	192	168	115	122	126	120	94	126
Final weight	179.6	174.7	180.4	177.8	178.5	179.3	180.0	183.1
Avg. daily gain	.77	.77	1.21	1.11	1.07	1.18	1.35	1.13
Feed per 100 cattles gain	398.2	374.9	384.6	394.1	396.8	364.6	359.9	380.3
No. slaughtered	6	— †	8	8	7	7	8	— †
Dressing percent*	71.1	—	77.1	74.9	74.4	72.4	72.2	—
Length of small intestine (Chinese feet) **	47.1	—	50.4	49.8	49.1	54.3	66.9	—
Caul fat, percent *	3.40	—	3.26	2.75	2.48	2.12	2.67	—
Kidney fat percent*	4.55	—	3.14	3.24	2.76	2.20	2.70	—
Back fat (cm)	3.75	—	4.75	4.26	7.50	6.21	4.40	—

* Percent of live weight.
** Chinese foot = 1/3 meter.
† Data lost in evacuation of Nanking

Table 10. Average dressing percentages (based on warm carcass weight) of various groups of hogs.

Breeding of pigs	No. of pigs	Dressing percent and std. error
Hampshire	15	72.7 ± 1.04
Berkshire	7	76.8 ± 0.85
Native (Chiangpei)	42	75.3 ± 0.43
Native (Chihhsu) *	6	72.1 ± 0.58
Hampshire x native	15	76.9 ± 0.51
Berkshire x native	20	75.1 ± 0.76
Chester White x native	4	77.1 ± 0.19
Yorkshire x native	18	72.5 ± 0.60
Duroc Jersey x native	8	72.1 ± 0.76
Poland China x native	7	76.1 ± 0.60

* Butchered at lighter weights than other groups.

Table 11. Summary of data on caul and kidney fat in carcasses from various groups.

Group	Average and standard error	
	Caul fat (cattles)	Kidney fat (cattles)
Modern breeds	3.06 ± 0.20	3.71 ± 0.27
Modern x native	4.66 ± 0.09	5.18 ± 0.12
Native (Chiangpei)	7.01 ± 0.41	8.63 ± 0.44
Difference between:		
Modern and crossbred	1.60 ± 0.22	1.47 ± 0.29
Native and crossbred	2.35 ± 0.42	3.45 ± 0.46
Modern and native	3.95 ± 0.42	4.92 ± 0.51

Table 12. Summary of data on thickness of back fat and skin, taken at the top of the shoulder.

Group	Average and standard error	
	Back fat (cm.)	Skin (cm.)
Modern	4.47 ± 0.21	0.20 ± 0.005
Modern x native	5.70 ± 0.14	0.28 ± 0.011
Native	5.85 ± 0.26	0.33 ± 0.021
Difference between:		
Modern and crossbred	1.23 ± 0.25	0.08 ± 0.012
Native and crossbred	0.15 (not sig.)*	0.05 ± 0.024
Modern and native	1.36(significant)*	0.13 ± 0.021

* Actual standard error calculated but now unavailable owing to loss of records.

Table 13. Comparison of development of heart, liver and small and large intestines in modern, North-China native and crossbred pigs.

Breeding of pig	Average weight and standard error (cattles)		Average length and standard error (Chinese feet)	
	Heart	Liver	Small intestine	Large intestine
Modern	0.49 ± 0.08	2.86 ± 0.15	61.3 ± 1.44	15.2 ± 0.46
Modern x native	.52 ± 0.01	2.62 ± 0.06	54.9 ± 1.45	16.1 ± 0.13
Native	.46 ± 0.01	1.92 ± 0.07	45.1 ± 0.50	15.3 ± 0.40
Difference between:				
Modern and crossbred	0.03 ± 0.02	0.27 ± 0.14	6.4 ± 2.04*	0.9 **
Modern and native	.03 ± 0.08*	.44 ± 0.15*	16.2 ± 1.56*	1 **
Crossbred and native	.06 ± 0.08*	.71 ± 0.09*	11.8 ± 1.54*	.8 **

* Significant differences
** These differences were not significant

Table 14. Performance of Haichiang and Tungchang native pigs, and crosses with modern breeds. Five pigs per litter were used.

Items compared	Breeds of pigs									
	Tungchang native	Haichiang native	Berkshire x Tungchang	Berkshire x Haichiang	Yorkshire x Tungchang	Yorkshire x Haichiang	Chester White x Tungchang	Poland China x Haichiang		
Initial weight*	33.4	30.3	29.3	37.2	30.6	36.0	28.6	31.1		
Days on feed	224	230	181	186	161	202	179	171		
Final weight	183.6	187.1	181.5	183.2	183.1	180.8	182.2	182.3		
Avg. daily gain	0.67	0.69	0.82	0.78	0.95	0.72	0.86	0.88		
Feed per 100 cattles gain	487.0	524.5	448.8	420.8	436.4	474.2	449.6	425.2		
Length of bristles (cm) **	3.24	3.04	3.38	2.82	4.61	2.85	3.03	3.40		
No. slaughtered	5	3	4	4	5	5	5	5		
Dressing percent	65.9	61.8	64.3	67.6	73.2	64.8	64.8	65.1		
Length small intestine †	62.0	64.5	63.9	60.4	59.4	54.5	65.5	66.7		
Caul fat(percent)	2.46	1.96	1.01	2.05	2.08	2.14	1.76	1.47		
Kidney fat(percent)	2.94	2.42	2.08	2.39	2.74	2.10	1.75	1.97		
Back fat (cm.)	5.18	5.93	4.35	4.05	4.89	5.42	7.88	4.50		

* In cattles. Catty = 1/2 kilo, or about 1.1 pound.
** Bristles over withers.
† In Chinese feet. Foot = 1/3 meter

Table 15. Growth of pur-bred, native and crossbred pigs under native farm conditions.

Breeding of pigs	Number at beginning	Number at end	Average initial		Average final	
			Age (days)	Weight (cattles)	Age	Weight
Native	4	1	100	30.0	390	186.0
Native	3	2	120	41.0	288	68.0
Berkshire	4	2	100	27.0	352	70.5
Berkshire	2	2	160	40.5	304	100.5
Hampshire	4	3	100	33.8	390	119.3
Large Yorkshire	7	4	154	41.5	346	126.6
Chester White x native	4	2	120	31.0	288	129.0
Duroc Jersey x native	4	3	100	34.5	340	151.7

Summary and Conclusions

Chinese swine are divided roughly into two main groups, the North- and South-China types. Much variation exists in both types and the South-China type may be divided into a number of sub-types. The types and subtypes are described insofar as available information will permit.

Available data on the performance of the Chinese hogs and of modern purebred and modern × Chinese crossbreds are summarized. These data are limited and conclusions must be tentative, but they indicate the following:

1. Chinese native hogs become sexually mature at an earlier age than modern American and English hogs.
2. The North-China sows appear to be more prolific than most of the South-China sows and modern sows.
3. The Chinese native sows appear to be somewhat better mothers, as judged by the percentage of pigs weaned.
4. Sows of the North-China type wean a greater total weight per litter than modern sows, owing to larger initial litter size, and better survival.
5. Individually, modern and modern × native crossbreds gain much more rapidly than native pigs, during both the nursing and fattening periods, and reach a larger mature size.
6. Data on efficiency of feed utilization give some indication that native animals tend to be less efficient than the modern and modern × native crossbreds, but in some trials no difference was apparent.
7. Native Chinese hogs, especially those of North China, tend to store up more internal fat during the fattening period than modern and modern × native crossbreds. At comparable weights the North-China native hogs also had a thicker layer of back fat than the modern breeds while crossbreds were intermediate. Direct comparisons were not made between modern and South-China native types, but crossbreds exceeded the native pigs in thickness of back fat in some cases.
8. Chinese swine usually produce stiffer, longer bristles than the modern breeds.
9. The environment under which the Chinese hog is born and raised is less favorable than that usually provided in the United States. Information is not yet sufficiently complete to indicate how well modern and modern × native pigs can compete with native pigs under Chinese farm conditions.

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Supplement with Vitamin C carrier three times a week.

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2714 WEST 35TH STREET **CHICAGO 90, ILLINOIS**